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Pp. 83-88 Figs. 2

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ABSTRACT

An Iron Fulgurite from Nebraska

C. M. RILEY

From the time of the ancients man has been impressed with the force of lightning and its effect on the rocks at the surface of the earth. It was Saussure in 1786 who first wrote a scientific account of a true fulgurite, and a wealth of literature has been written about the subject since this time. Many unusual fulgurites have been described, some of which may not truly be the result of lightning. The iron fulgurite is a strange conical object about 3 inches high composed mainly of tiny spheres and filaments of metallic iron intermixed with a small amount of nonmetallic soil minerals. It is believed that a bolt of lightning hit an iron object lying in a farmyard, instantly melted it, and somehow sprayed the molten iron into the soil where it solidified. The power needed by a lightning bolt to instantly melt a mass of iron this size was computed at 2050×10^6 watts.

CONTRIBUTION OF *the Department of Geology, College of Arts and Sciences, and the Division of Geology of the Museum.*

Riley[1]

An Iron Fulgurite from Nebraska

Introduction

Mankind has always held in awe the fearful power and mystery of lightning. Early writers considered lightning bolts the weapons of the gods, and Pliny writes of two kinds of stones, the *ceraunia* and the *glossopetra* which supposedly could only be found where lightning had struck. Many fossils and artifacts found during the middle ages were attributed to the effect of lightning. The *ceraunia* were thought to be excellent charms to protect the wearer from lightning or severe storms, and when taken internally they provided a cure for several diseases (Adams, 1938).

Barrows (1910), in his excellent review of the literature on fulgurites, tells of Horace Benedict Saussure who wrote in 1786 what was probably the first scientific account of the effect of lightning on rocks from the summit of one of the outlying peaks of Mount Blanc. Petty (1936), in his historical review of the subject, credits a Pastor David Hermann with having found fulgurite tubes for the first time in Germany in 1706. Since then there have been a great number of papers concerning fulgurites. Most of these are merely descriptions of the locality and the nature of particular fulgurite finds, but Julien (1901)

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gives a comprehensive petrographic report and classifies fulgurites as either: 1) superficial—glassy crusts on rock surfaces, or 2) internal—actual tubes in unconsolidated material. At the present there is such a wealth of evidence, even eye-witness accounts, that no one can doubt the lightning origin for these objects. However, even from the time of Saussure this conclusion has been strengthened by laboratory experiments which created fulgurites in a variety of materials by comparatively feeble sparks (Petty, 1936).

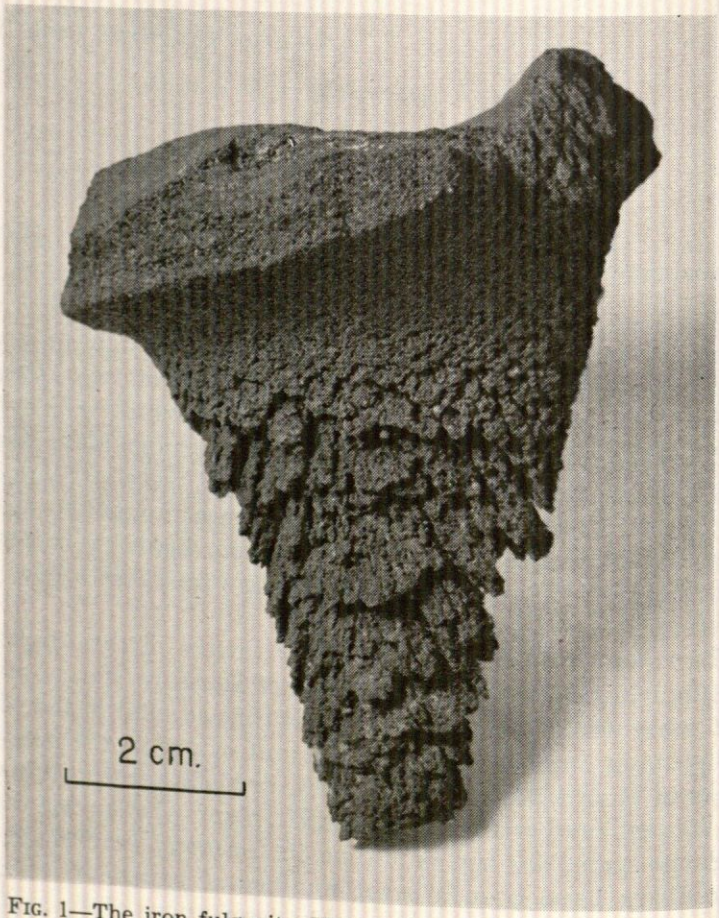

FIG. 1—The iron fulgurite, University of Nebraska State Museum Cat. No. G-19.

Most fulgurites are from sandy areas such as beaches or dunes. In such localities shifting sands quickly uncover the tubes and buried "roots" are easily dug out. However, fulgurites have been reported from nickel-bearing serpentine (Ash-

ton and Bonney, (1896), on a variety of igneous and metamorphic rocks (Julien, 1901), and even from a concrete sidewalk (Hill, 1947). An unusual occurrence is reported by Cook (1925). He describes fulgurites which consist of nearly 50% manganese dioxide. This writer has had an opportunity to examine these specimens and must admit their striking external similarity to sand fulgurites. However, their structureless nature, their thickness, and the absence of any fused quartz (lechatelierite) makes one wonder whether the filling of root cavities in the soft Oligocene rocks could not have produced the so-called fulgurites.

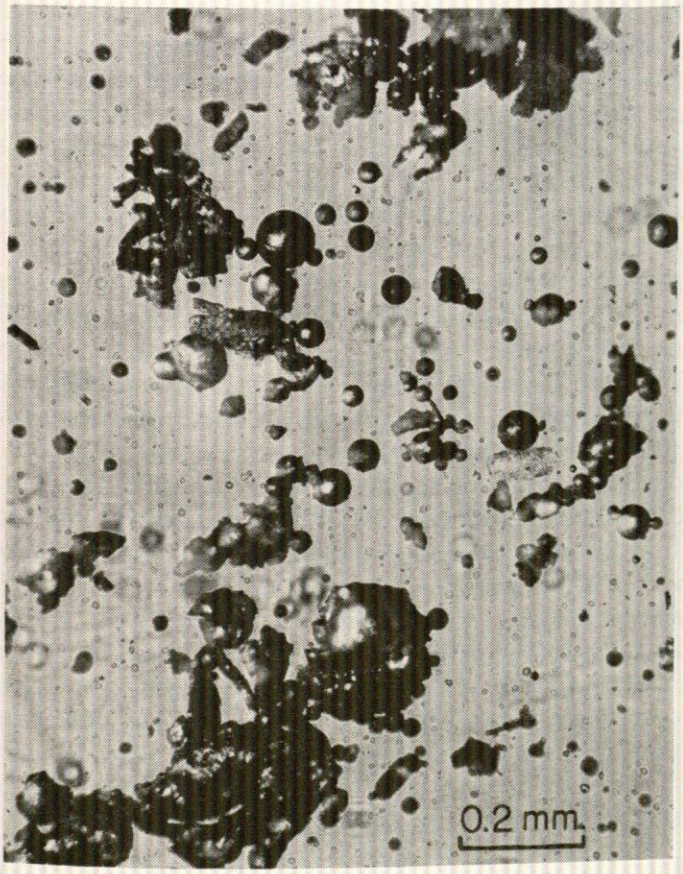

FIG. 2—Photomicrograph of grains from iron fulgurite showing spheres, filaments, and irregular masses of iron.

THE IRON FULGURITE

The specimen (University of Nebraska State Museum Catalogue Number G-19) was brought to the University of

Nebraska State Museum for identification by Mr. Milton Oberhauser of Eustis, Nebraska. It was picked up in a farmyard in April 1955 where it was lying on the surface of the ground.

The object (see Figure 1) is shaped like a cone. Its base is irregular in shape, about 2½ inches in diam., and appears to have been broken from a larger piece. The conical part is about 3 inches high but has been broken at the top. It weighs 273.3 grams. The color is black, although in places it shows a yellowish-brown limonite staining on patches of fine sand. At the base of the cone there are smooth indentations as though it had once been molded against something, but the rest of the specimen is granular and very friable. The prominent vane-like protrusions from the side of the cone reflect a "grain" that can be seen along the broken edge of the base. On the opposite side the base shows a layered nature. It is very porous and presents a rough appearance when viewed with a hand lens.

The grains, which easily rub off of the surface, were mounted in balsam and examined under the microscope (see Figure 2). About 95% of the grains are metallic iron which occurs in three different forms. Most common are the spheres of iron which range in size from 0.01 mm to as much as 0.15 mm in diameter. Most of these are perfect spheres, but many have small points as though they started out as teardrop shapes. Filaments of iron are very plentiful, and some are as long as 2.0 mm, although the average length was estimated at about 0.5 mm. Some of the filaments are ribbonlike, and in all of them the width is quite variable. The rest of the iron occurs in irregular clumps which seem to be aggregates of spheres and filaments. The largest of these clumps is about 2.0 mm in diameter.

The nonmetallic mineral grains are all less than 0.1 mm in diameter and were identified as quartz, mica, clay and some feldspar. These minerals are all present in the Pliocene Ogallala formation, which underlies the Eustis area.

Origin of the Iron Fulgurite

When the object was first examined it became at once apparent that great heat was involved in its formation, for the iron had certainly been molten before it solidified as the tiny spheres and filaments. An ordinary fire seemed inadequate because it would not cause the finely divided state of the iron. Three possible explanations for the object seemed likely: 1) it

is an iron meteorite which was completely molten as it hit the earth and was sprayed downward by the force of the impact; 2) it is an accumulation of iron droplets built up somehow from the blast of the welder's torch; or 3) it formed when a bolt of lightning hit an iron object lying in the barnyard, instantly melted it, and somehow sprayed the molten metal into the soil.[1]

The extraterrestrial origin was ruled out when tests showed that no nickel was present. Also it does not seem likely that a meteorite which is melting from the outside in because of friction would hold together as a 200-gram mass of molten material. It is more likely that as the outer layer of a meteorite melted the liquid would slough off in the slip stream, and no large mass of molten metal would ever be present at one time. Since Mr. Oberhauser is very certain that there has been no welding in the farmyard, the origin by lightning seems to be the only answer.

Even though iron is a far better conductor of electricity than is quartz, it is not difficult to imagine a bolt of lightning powerful enough to melt a small iron object. A force so strong that it could form a fulgurite tube of fused quartz (melting point 1713°C) to a depth of 50 feet (West, 1843) could easily account for such a small mass of molten metal. Even so it is interesting to compute the amount of energy which must have been expended in the melting of the iron during the short duration of a lightning flash. If we assume that the original iron object weighed 200 grams and that it was pure iron, a total of 49,000 calories was required to heat it to the melting point (1530° C) and change it to a liquid. Using Joule's constant (4.185×10^7 ergs per calorie) and Rogers' (1946) figure of 100 microseconds (100×10^{-6} seconds) for the duration of a lightning discharge, we arrive at the value of 2050×10^6 watts, for the power necessary to form the iron fulgurite. Of course, many approximations and assumptions affected the accuracy of this figure, and it does not even take into account the force required to break up the molten mass into droplets and to impel these droplets into the soil. No explanation for this effect presented itself. The necessary power computed above is but a tiny fraction of the 10^{15} watts known to be available (Loeb, 1949) in an ordinary bolt of lightning.

[1] Dr. A. L. Lugn of the Dept. of Geology, University of Nebraska first made this suggestion.

Although this object does not resemble in any way the tubes and rock glazes which have been called fulgurites, the writer feels that the term "iron fulgurite" should be applied because of its supposed origin.

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